Proposed Ph. D. Synopsis

On

Diagnosis of Retinal Detachment Using Fuzzy Based Classification and Image Segmentation Techniques

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Abstract

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Abstract:

The retina, the innermost layer of the eye, receives circulation from the choroidal and retinal vessels and contains vital components such as the aqueous humor, vitreous humor, and lens. Retinal detachment (RD) occurs when the sensory retina separates from the retinal pigment epithelium, leading to potential severe visual loss if not treated in time. In some cases, retinal tears may be accompanied by vitreous hemorrhages, further complicating the condition. If the retina is not promptly reattached, permanent vision loss may result. While RD often causes visual impairment, early diagnosis significantly improves the chances of successful reattachment and better visual outcomes, especially before macular involvement. However, identifying RD at an early stage remains a challenge, as it often begins asymptomatically and progresses from the peripheral retina. Even when symptoms such as flashes, curtains, and increasing floaters appear, many patients mistake them for normal aging or minor vision issues, delaying medical intervention.

In this research, we aim to introduce and extract new features for retinal detachment detection under the guidance of ophthalmologists. These features include:

- Color variations in the detached retinal area
- Blood vessel
- Retinal area measurement
- Floaters present in the vitreous fluid

The dataset used for this study consists of authorized retinal detachment fundus images, ensuring reliability and standardization in data collection. Unlike previous research that primarily focuses on floaters and blood vessels, our approach integrates multiple retinal features, providing a more comprehensive assessment of retinal detachment.

To achieve high diagnostic accuracy, we apply various fuzzy-based classification techniques to classify the stages of retinal detachment. These techniques are evaluated to determine their effectiveness in enhancing diagnostic precision. Additionally, expert opinions from ophthalmologists are incorporated into the analysis to validate the results and further improve the classification performance.

Key Contributions

1. New Feature Extraction for Retinal Detachment: Expanding beyond floaters and blood vessels by analyzing color, retinal area, and vessel morphology for better diagnosis.
2. Expert-Guided Validation: Collaborating with ophthalmologists to enhance feature selection and classification reliability.

Introduction:

Retina is in the innermost layer which gets its circulation from the vessels of the choroid and the retinal vessels. Within these layers are the aqueous humor, the vitreous humor and the lens [1], [2].RD is a separation of the retina, which is the light sensitive membrane from its attachments to the underlying tissue within the eye. On occasion retinal tears are also accompanied by vitreous hemorrhages. If the retina is not reattached soon, permanent vision loss may result [3]. Although RD often causes visual disability and visual loss, the early diagnosis of RD can improve the rate of successful reattachment and the visual results, especially before macular involvement [4]. However, identifying RD at an early stage remains challenging, as RD often starts asymptomatically and progresses from a small size at the peripheral retina [5]. Even in patients who perceive early RD symptoms, such as flashes, curtain, and increasing floaters, 17% of these patients attribute these changes to aging or problems with their glasses or contact lenses [6].

Retinal detachment (RD) occurs when the sensory retina separates from the retinal pigment epithelium, which may lead to severe visual loss if not treated timely

Therefore, patients rarely visit a doctor in a timely manner until the symptoms aggravate or visual acuity sharply drops13. As result, the best timing of treatment can be missed and irreversible visual loss may occur. Consequently, it is essential to develop an appropriate screening approach to detect RD at an early stage.

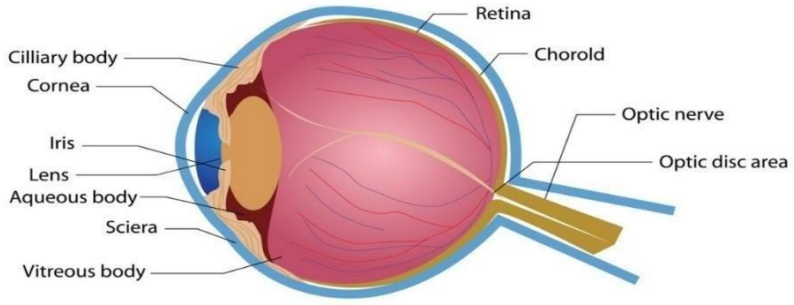


Fig 1: Anatomy of Human eye

Retinal detachments are by using the flowing symptoms:

1. Increase number of flashes in front of eye. It is
2. also called photopsia.
3. Increase number of floaters in front of eye.
4. Loss of vision.
5. Blurred vision.
6. Reduced side (peripheral) vision Etc….

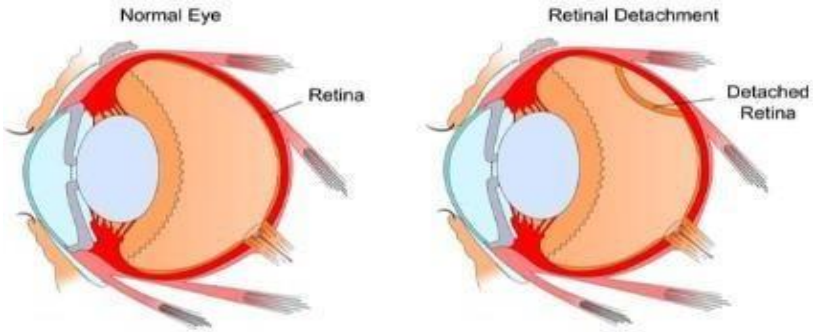


Fig 2. show the difference between normal eye and retinal detachment eye.

2. Definition of the Problem:

Retinal detachment (RD) is a serious eye condition where the retina separates from its underlying support tissue, leading to vision loss if not treated promptly. Research in this domain faces several challenges that hinder the understanding, diagnosis, and treatment of the disease.

As the review of literature survey Current work done on Oct base Images, UWF images, but the Retinal detachment was not diagnosis properly

In the early stages, RD may not present clear symptoms, making early detection difficult. Current diagnostic tools like fundoscopy or OCT (Optical Coherence Tomography) may not always identify subtle or peripheral detachments. RD can be confused with other retinal conditions such as macular degeneration or posterior vitreous detachment.

In the existing methodology some used OCT (optical Coherence tomography) for extracting some features of retinal detachment. But the it is capturing small size of retinal image to it is very difficult to camper with another or extract some features of retinal detachment.[18]

Zhongwen Li and et.al present study verifies that our robust cascaded deep learning system can be applied to identify RD and discern macula-on/off RD but UWF imaging can capture the largest retinal view compared with other existing technologies, this method still could not cover the whole retina. Hence, our deep learning system may miss a few RD diagnoses that are not captured by UWF imaging [19].

3. Objectives

1. Study on retinal images capture by funds camera by using authorized data set.
2. Try to extract retinal features by using various image segmentation techniques.
3. Classify by using fuzzy based classification compare with another classification techniques for more accurate diagnostic results.
4. Grading level of Retinal detachment disease

4. Literature Review:

There is some literature survey that we have done , this literature survey is based on retina, retinal diseases, some feature for extracting the retinal detachment, methodology etc.

L. Poongothai1 , Dr. K. Sharmila proposed Segmentation color map analysis to identify retinal detachment in this study the segmentation of eye floaters in the vitreous fluid of the eye. By using color mapped they identify the detached tissues in the eye. After that histogram analysis by using grayscale thresholding value provide the detail information about the normal eye and detached eye. [7]

K.Deviga, Dr.T.RathaJeyalakshmi proposed BRVO segmentation in fundus image using machine learning approach for retinal detachment in this study The proposed method put to use an combination of level set with region based active contour methods. After the comparison of proposed method and other methods. This proposed method achieves an accuracy of 90%., sensitivity is 1, specificity is 86.9%, precision is 73% and f1 score 84%[8].

Katharina Eibenberger, Michael Georgopoulos, Sandra Rezar-Dreindl, Ursula Schmidt-Erfurth, and Stefan Sacu proposed Development of Surgical Management in Primary Rhegmatogenous Retinal Detachment Treatment from 2009 to 2015 in this study they measures were the type of surgical procedure ((scleral buckle (SB), pars plana vitrectomy (PPV), combination of SB and PPV or cryocoagulation (CC)) and intraocular tamponades. In addition, functional outcome an d intra/postoperative complications were assessed over the observational period.[9]

Mohamed Akil, Yaroub Elloumi, Rostom Kachouri proposed Detection of Retinal Abnormalities in Fundus Image Using CNN Deep Learning Networks in this paper they used methods which is based upon DL and CNNs for identify the retinal abnormalities which is related to the most severe ocular diseases in retinal images, in this study they present some related work regarding the Deep Learning-based Smartphone applications for earlier screening and diagnosis of retinal diseases.[10]

Zhongwen Li, Chong Guo, etc Proposed Deep learning for detecting retinal detachment and discerning macular status using ultra-wide field fundus images In this study, they developed a cascaded deep learning system based on the ultra- wide field fundus images for automated retinal detachment detection and maculaon/ off retinal detachment discerning. By using this system can automatically provide guidance to patients regarding appropriate preoperative posturing to decrease the retinal detachment development and the urgency of retinal detachment repair. The implementation of this system on a global scale may drastically reduce the extent of vision loss resulting from retinal detachment by providing timely identification of disease.[11]

Tuan D. Phaml, Dat T Tran, Marianne Brown, R. Lee Kennedy Proposed IMAGE SEGMENTATION OF RETINAL VESSELS BY FUZZY MODEL in this study they proposed some fuzzy module which can identify the large retinal blood vessels. However both i.e. edge-detection base and fuzzy-model base segmentation method cannot find the thin vessels in retina. But some fuzzy models used for identifying retinal vessels in images which are subjected to inconsistent contrast and vague boundaries. [12]

Gupta, Rajeev; Singh, Pramod Kumar; Kumar, Basant; Singh, Abhishek; Chandra, Proposed, Automated Detection of Retinal Detachment from Ocular Ultrasound using Image Thresholding in this study, development of the ultrasound image is done first and then region of interest (ROI) is fixed to locate vitreous region. After that thresholding (Binarization) and inversion of ROI are performed on that. In last stage, morphological operations are performed for computing percentage of detached retina (PDR) and identification of the nature of detached retina (NDR).[13]

Syed Omer Gilani,Tooba, Adeeb Shehzad, Mohsin Jamil, Shafaq Mushtaq, Sumbal Mushtaq, Asim Waris Proposed Automated Classification of Retinal Diseases in STARE Database in this study they MATLAB for preprocessing and for automated identification and classification the A support vector machine classifier was used. The main of this paper is to developed the tools for STARE database classification using SVM , but the using purposed algorithm not detected few disease. And the training images set consists of 3 positive samples set and 127 negative samples for some of the diseases.[14]

Rajeev Gupta & Vishal Gupta & Basant Kumar & Pramod Kumar Singh & Amit Kumar Singh proposed A novel method for automatic retinal detachment detection and estimation using ocular ultrasound image this very difficult method because they not diagnose the retinal detachment. It is very hard to extract the features of retinal detachment by using Ultra sound images due to very low quality. In this we study calculation of different detachment parameters for retinal detachment.[15]

5. Methodology

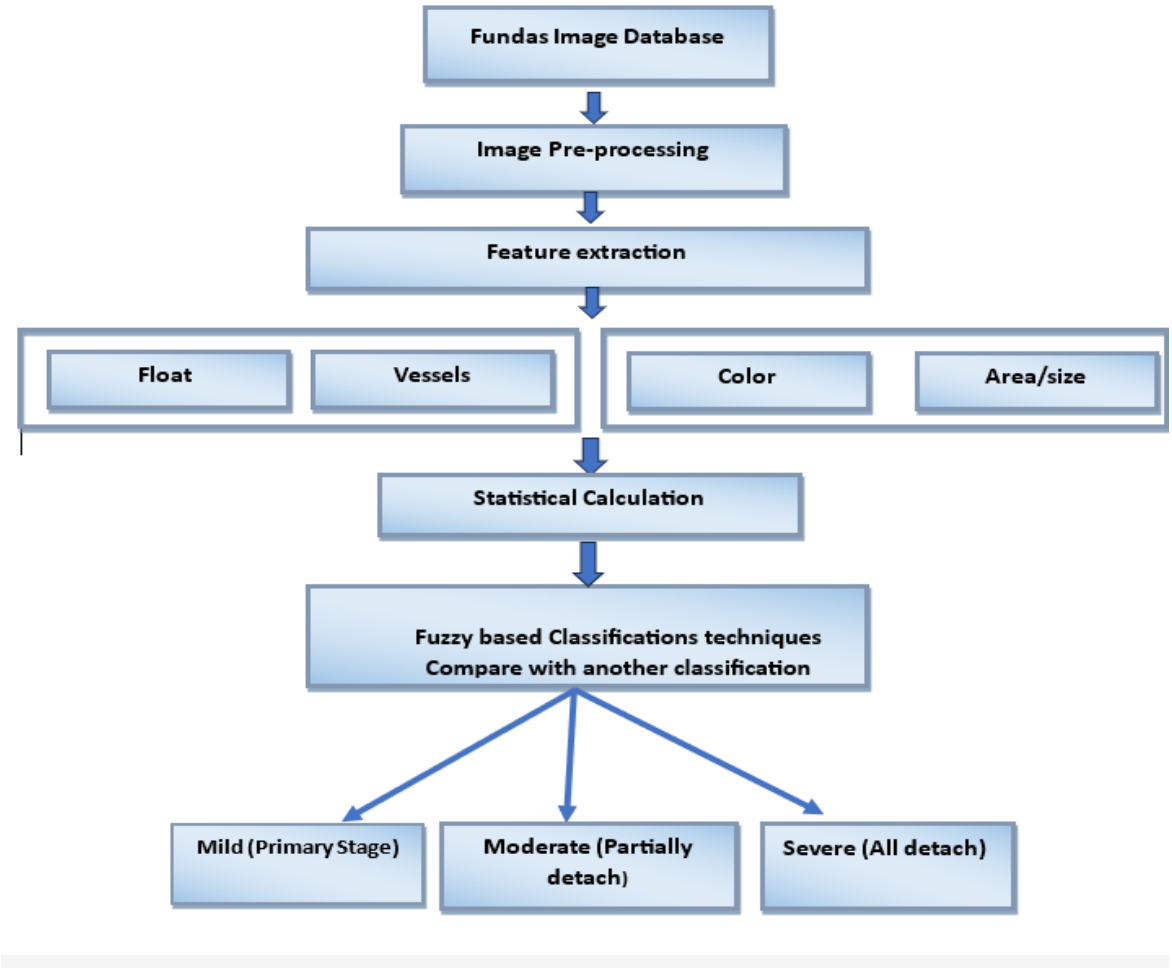


Fig. 3. Proposed Methodology

5.1 Database:

SATRE Database

The database is an organized collection of structured data to make it easily accessible, manageable and update. a database in a place where the data is stored.

The STARE (STructured Analysis of the Retina) Project was conceived and initiated in 1975 by Michael Goldbaum, M.D., at the University of California, San Diego. It was funded by the U.S. National Institutes of Health . During its history, over thirty people contributed to the project, with backgrounds ranging from medicine to science to engineering. Images and clinical data were provided by the Shiley Eye Center at the University of California, San Diego, and by the Veterans Administration Medical Center in San Diego.

1. The full set of ~400 raw images in the STARE database can be obtained here. Small versions of all the images can be viewed 100 at a time: 1-100, 101- 200, 201-300, 301-400.
2. List of diagnosis codes and diagnoses for each image.
3. Expert annotations of the manifestations (features) visible in each image, tabulated here in text files. A total of 44 possible manifestations were queried to the experts during data collection and then reduced to 39 values during encoding. This mapping provides details.
4. Blood vessel segmentation work including 40 hand labeled images, our results, and a demo.
5. Artery/vein labelings of 10 images done by expert 1 and expert 2.
6. Optic nerve detection work including 80 images with ground truth, and our results.

IEEE Database

The fundus images for non-retinal detachment and retinal detachment were collected from the four-eye hospital in the country namely Silchar medical college and hospital (Assam), Aravind eye hospital (Tamil Nadu), LV prasad eye hospital (Hyderabad) and Medanta- The medicity (Gurugram). A total of 1693 images have been collected from these hospitals in which 1017 fundus images belonged to retinal detachment and the rest 676 were non-retinal detachment. The dimension of these images were fixed to the pixel size of 1000×1000×3.

5.2 Image Preprocessing:

Image pre-processing is the term for operations on images at the lowest level of abstraction. These operations do not increase image information content but they decrease it if entropy is an information measure. The aim of pre-processing is an improvement of the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis task.

In the Pre-processing we remove the noise from the background and enhance the image. also resize images for better visualization or to fit them into a specific layout. After that we convert the RGB image into LAB color space LAB is less sensitive to lighting changes compared to RGB. This makes it advantageous for picture handling assignments where you need to maintain color consistency despite variations in illumination. Also used the histogram

Equalization on the Gary scale image rearranging the intensity values to enhance contrast.

Noise Reduction: Methods like Gaussian filters, median filters, or bilateral filters are used to remove unwanted noise from images while preserving important details.

Normalization: Adjusts pixel intensity values to a common scale for consistent analysis. Common techniques include histogram equalization and contrast stretching.

Smoothing: Reduces variations between adjacent pixels, making the image less jagged and more visually coherent. Often achieved using low-pass filters.

Edge Enhancement: Highlights boundaries and sharp features in the image using techniques like Sobel or Canny edge detection.

Background Removal: Eliminates irrelevant background to focus on the region of interest (ROI).

Segmentation: Separates objects of interest from the background or partitions the image into meaningful regions.

After collection of fundas images database, we has been done preprocessing techniques on database.

1) Resizing Image :all images fixed size of 256 × 256 pixel.
For that we used following formulas .

$$I_{resized(x',y')} = I\left(\frac{x' \times W_{orig}}{W_{new}} \times \frac{y' \times H_{orig}}{H_{new}}\right)$$

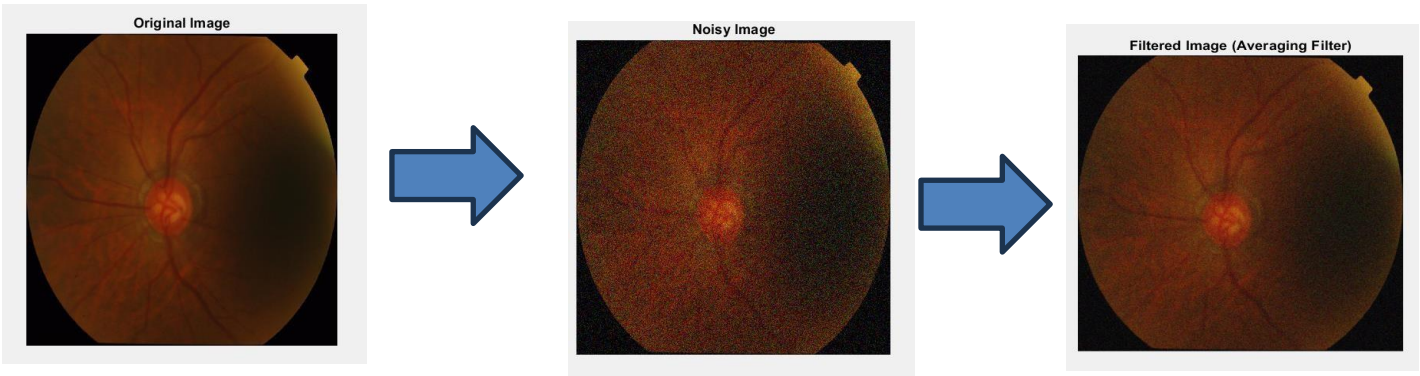
Where:

- $I_{resized}$ is the resized image.
- $I(x, y)$ is the original image.
- W_{orig} , H_{orig} are the width and height of the original image.
- W_{new} , H_{new} are the target width and height (256×256 in this case).
- x', y' are the new pixel locations.

2) Noise Reduction:

1. Averaging Filter:-

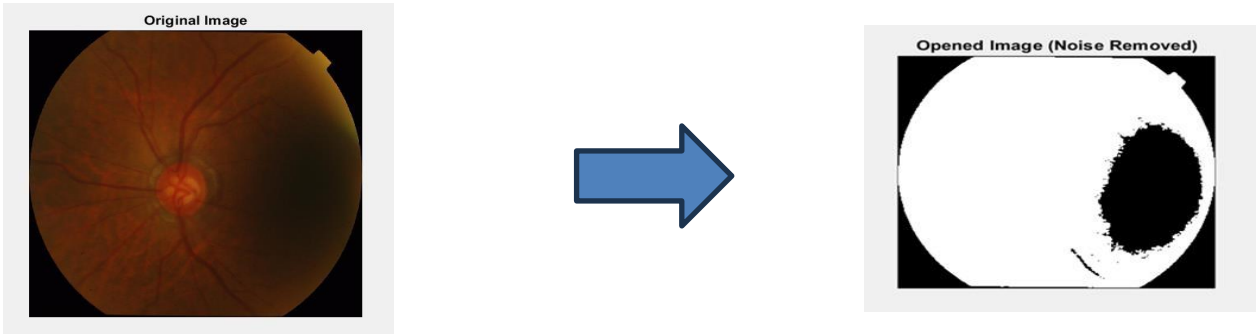
Averaging filters are effective at reducing random noise in images by averaging out the fluctuations. They are used to create a smoother, less grainy image, often used as a preprocessing step before other image processing techniques.



Original Image **Noise in the Image** **Filter Image**

2. Morphological filtering: -

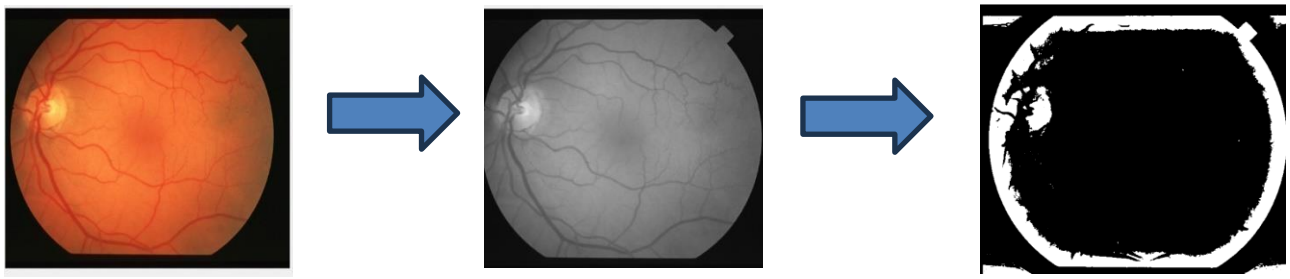
Morphological operations can effectively remove salt-and-pepper noise, which appears as isolated bright or dark pixels. Morphological filtering can be used to isolate and enhance specific features in an image, such as edges or objects. Morphological operations can help to separate objects from the background and clean up segmentation masks.



Original Image **Filter Image**

3. Conversion of RGB image to Binary image:

Converting an RGB image to a binary image involves reducing the color information of each pixel to just two values, typically black and white (or 0 and 1). It is used for extract key information from an image



RGB Image **Gray Image** **Binary image**

5.3 Feature Extraction

Feature extraction in image processing is a method of transforming large redundant data into a reduced data representation. Transforming the input data into the set of features is called feature extraction.

Segmentation techniques: Image segmentation is a branch of digital image processing which focuses on partitioning an image into different parts according to their features and properties.

On the basis of that we extract the four features of retinal detachment disease.

1. Float
2. Retinal Vessels
3. Retina color
4. Retina Area

On the basis of these features, we diagnosis the retinal detachment disease.

6. Statistical Calculations & Analysis

After collection of fundus image Database, we has been done some preprocessing technique on database

1. **RGB Color Separation**

Green channel is widely use in Image processing. Green channel is showing more features than red and blue channel .in following line we will see some formulas for RGB color Separation.[8]

Red Channel

$$r = \frac{R}{(R + G + B)} \quad (1)$$

Here we see Red channel .R , G, and B means that Red Green and Blue respectively.

2. Feature Extraction:

1. Image Resizing: Bilinear interpolation is commonly used for resizing:

$$I'(x', y') = \sum_{i=0}^{1} \sum_{j=0}^{1} w_{ij} I(x + i, y + j)$$

Where:

- I(x,y) is the original image.
- I′(x′,y′) is the resized image.
- w_{ij} are interpolation weights.

2. Image Filtering: A 9×9 averaging filter applies a mean smoothing operation:

$$I'(x, y) = \frac{1}{K} \sum_{i=-m}^{m} \sum_{j=-n}^{n} I(x + i, y + j)$$

Where:

K=81(total filter elements).

The filter reduces noise and smooths the image.

3. Otsu's Thresholding: Otsu's method finds the threshold T∗T^*T∗ by minimizing intra-class

$$T^* = \arg\min_T \sigma_w^2(T)$$

Where ,

$$\sigma_w^2(T) = q_1(T)\sigma_1^2(T) + q_2(T)\sigma_2^2(T)$$

Foreground: I(x,y)≤T*
Background: I(x,y)>T*

4. Binary Image Cleaning: This removes objects with area <100 pixels.

$$A_{\text{remove}} = \{I(x,y) | \text{Area}(I(x,y)) < T\}$$

a. Creating a Freehand ROI:

$$M(x,y) = \begin{cases} 1, & (x,y) \in \text{ROI} \\ 0, & \text{otherwise} \end{cases}$$

Where:

- M(x,y) is the **mask image**.
- Pixels inside the drawn region are set to **1 (white)**.
- Pixels outside the region are set to **0 (black)**.

b. Element-wise multiplication extracts the region of interest:

$$I_{\text{ROI}}(x,y) = I_{\text{gray}}(x,y) \times M(x,y)$$

c. Thresholding Method:

$$T^* = \arg\min_T \sigma_w^2(T)$$

d. Retina and Holes Area Calculation:

$$\text{Retina Area} = \sum_{x,y} B_{\text{clean}}(x,y)$$

$$\text{Holes Area} = \sum_{x,y} H(x,y)$$

7. Experimental Work

7.1 Experiment 1

Retinal detachment diagnosis using Float Parameter

The First parameter that we extract for Retinal detachment is float, if the float is present in the vitreous gel so it is first symptoms of retinal detachment it is possibility to Retinal detachment.

The following Image shows the difference between the normal Retina and Retinal detachment.

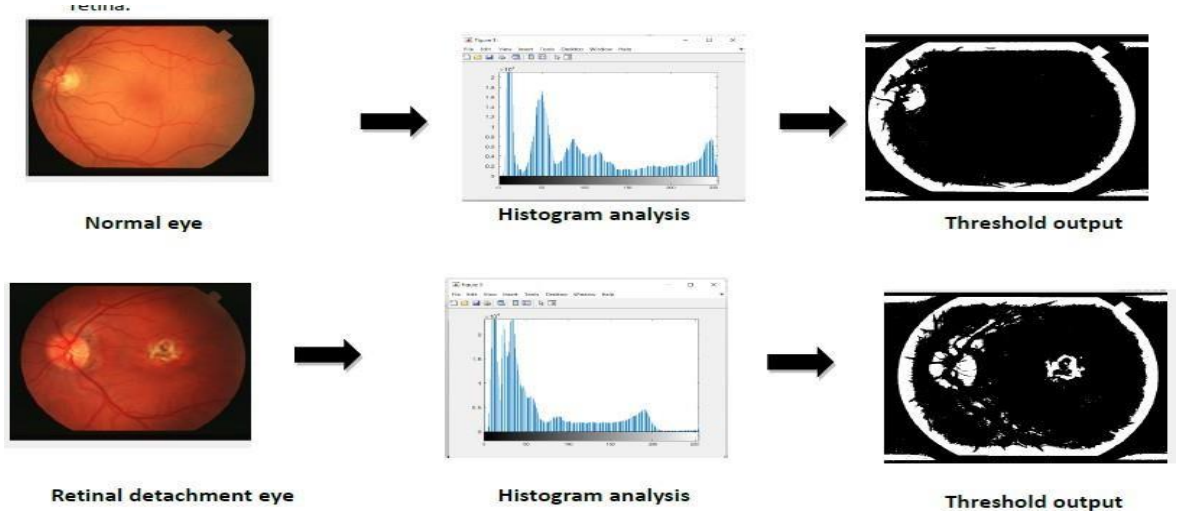


Fig4: Difference between health retina and retinal detachment

The above result indicates in Normal eye there are no floaters is present in the vitreous gel and in detachment eye there is floaters is present in the vitreous gel. In the histogram analysis, the histogram show, when the retina is detached at that position the pixel insensitivity automatically getting low.

Normal Retinal Images :Float parameter extraction from image

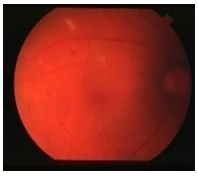
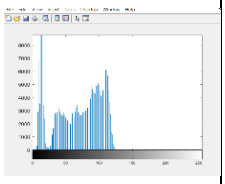
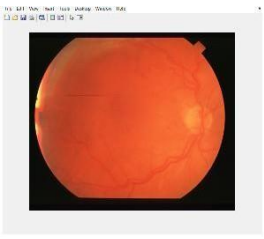
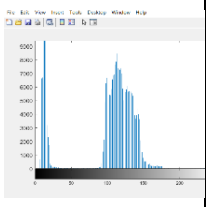
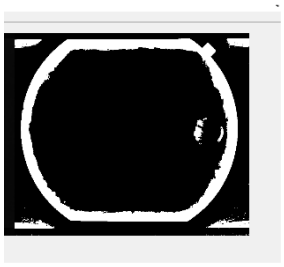
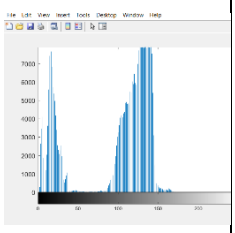
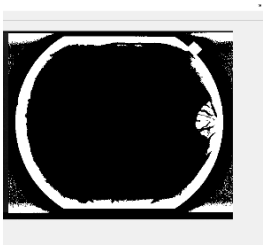
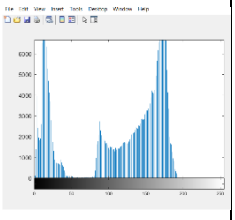
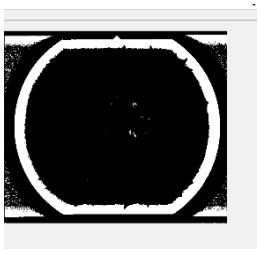
Sr no.	Color Image	Histogram Analysis	Binary Image	Threshold value
1				**113.43**
2				**128.984**
3.				**151.985**
4				**134.76**

Table1: Statistical Values for float parameter

Abnormal Retinal Images: Float parameter extraction from image

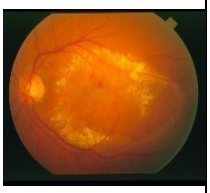
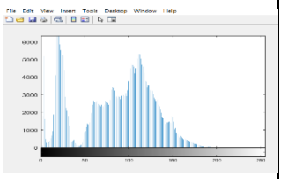
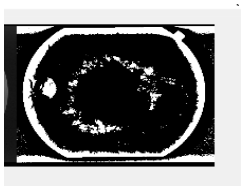
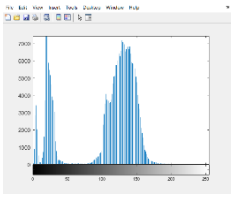
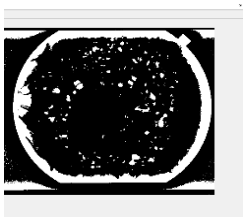
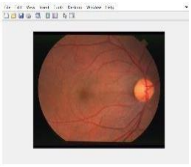
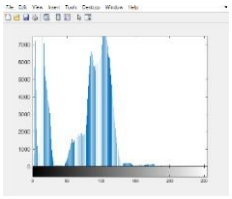
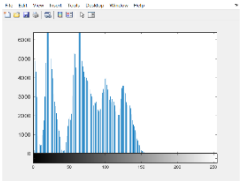
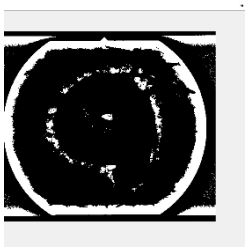
Sr no.	Color Image	Histogram Analysis	Binary Image	Threshold value
1				**44.5156**
2				**66.8862**
3				**80.6531**
4				**74.2204**

Table2: Statistical Values for float parameter

7.1.1 Conclusion of Experiment

The presence of floaters in the vitreous gel is considered an early symptom of retinal detachment, as suggested by ophthalmological studies. This indicates a possible risk of retinal detachment. Therefore, the presence of floaters can be considered a key parameter in identifying the initial stage of retinal detachment.

7.2 Experiment-2

Retinal detachment diagnosis using Retinal Vessels

The Second feature that extract the position of Retinal detachment is the blood vessels of retina. for extract the blood vessels following methods are used.Pre-processing, Applying Filters, Thresholding methods to extract blood vessels, Differences between Normal retina and detach retina.

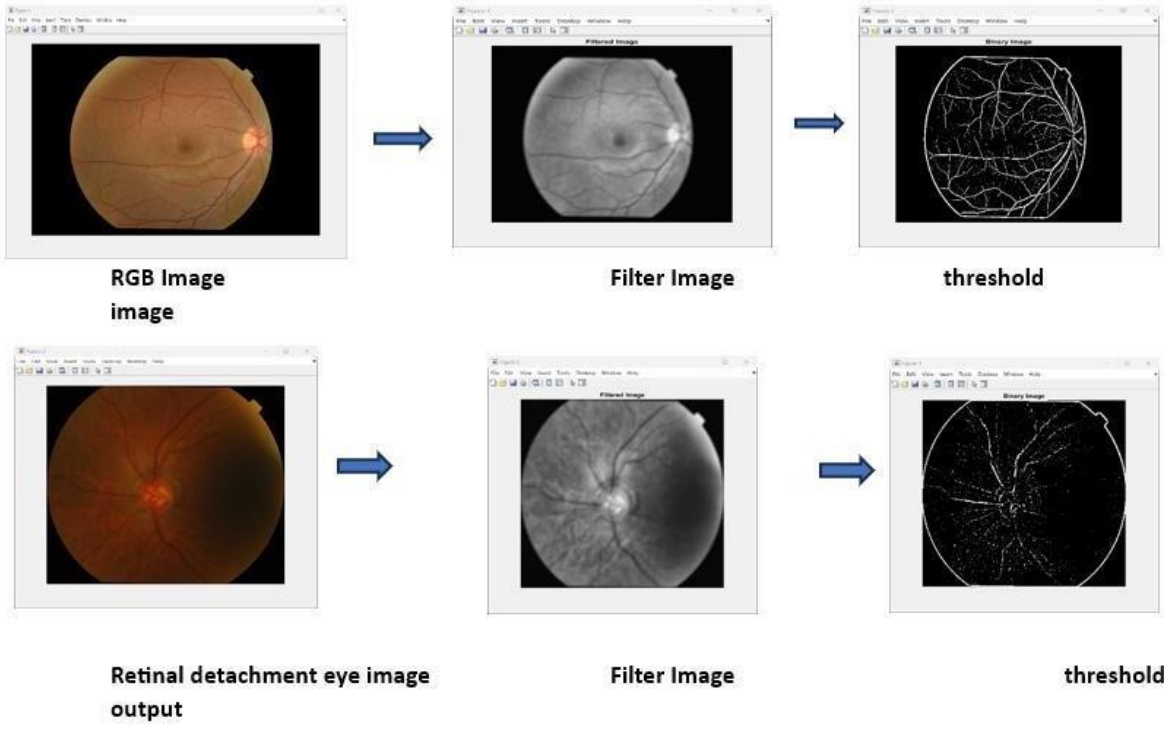


Fig 5. Comparison Between Normal Retina and Retinal detachment position from blood vessels

Retinal Vessels

Normal Retina		Detachment Retina	
IM000003_20.jpg	Present	ASRS-RIB-Image-61191_output.jpg	Absent
IM000004_1.JPG	Present	ASRS-RIB-Image-19704_output.jpg	Absent
IM000004_10.JPG	Present	254_output.jpg	Absent
IM000004_11.JPG	Present	RD4_output.jpg	Absent
IM000004_12.JPG	Present	macula on RD_output.jpg	Absent
IM000004_13.JPG	Present	55_output.jpg	Absent
IM000004_14.JPG	Present	342_output.jpg	Absent
IM000004_15.JPG	Present	490_output.jpg	Absent
IM000004_16.JPG	Present	43_output.jpg	Absent
IM000004_17.jpg	Present	ASRS-RIB-Image-5234_output.jpg	Absent

Table 3. Represent retinal vessels present and absent

Graphical Presentation

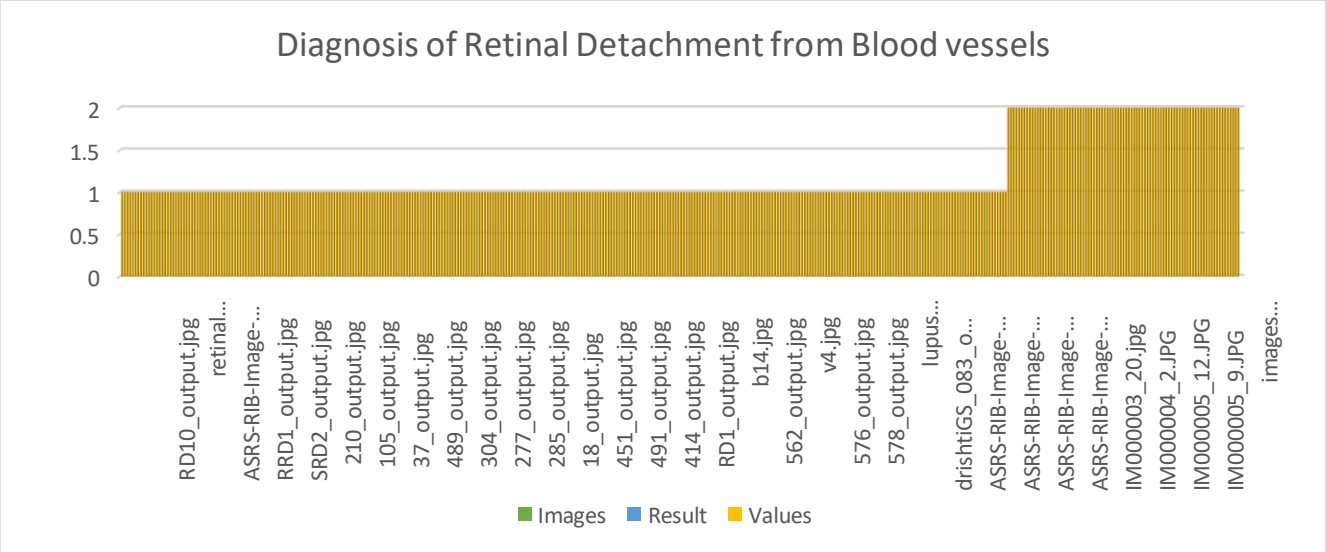


Fig 5. Graphical Representation of normal Retina and Retinal Detachment

7.2.1 Conclusion of Experiment

The bar chart represents the diagnosis of retinal detachment (RD) from blood vessels in retinal images. The x-axis lists the image filenames, while the y-axis represents the diagnosis values.

- **Value 1** indicates images classified as **RD (Retinal Detachment)**, meaning these images contain features suggesting retinal detachment.
- **Value 2** indicates images classified as **NRD (Non-Retinal Detachment)**, meaning these images show no signs of retinal detachment.
- Most images have a diagnosis value of **2**, suggesting they belong to the **NRD (Non-Retinal Detachment) category**.
- A small subset of images may have a value of **1**, indicating a diagnosis of **RD** and potential retinal detachment risk.

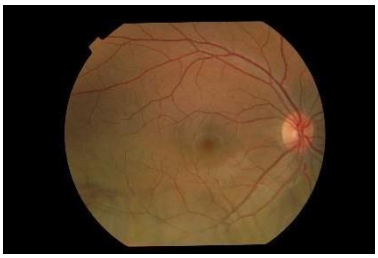
This analysis helps in identifying and distinguishing between normal and detached retinal conditions, which is crucial for early detection and treatment of

7.3 Experiment- 3:

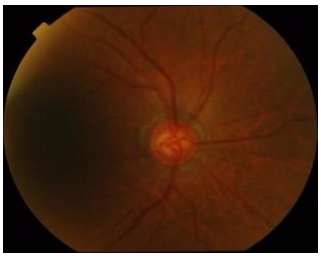
Retinal detachment diagnosis using Retina color

The Third feature we extract the retinal detachment position that color of retina. we discuss with ophthalmologist when the retinal detachment starts in retina then color of retina is changes

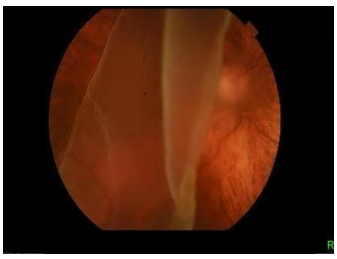
Following figure shows the Retina detachment.



Normal Retina



Retinal Detachment

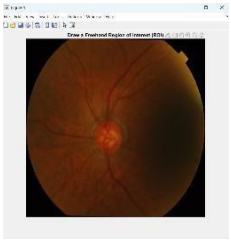
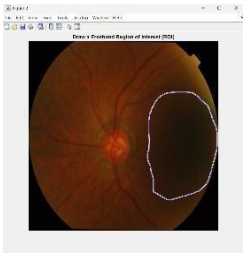
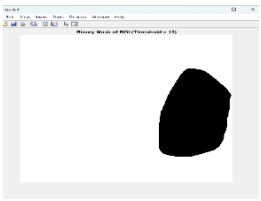


Retinal Detachment

In this feature extraction we used following process.

Preprocessing -Select Region of Interest -Extract ROI-Display result -Convert ROI to Binary Based on Threshold -Apply Threshold on ROI-Apply classification Techniques.

By using the Region of interest we select the position of RD and calculate the threshold value of that ROI and then used classification techniques for diagnosis of RD severity.

Image	Freehand ROI	Cropp RoI	Binary mask Image
			

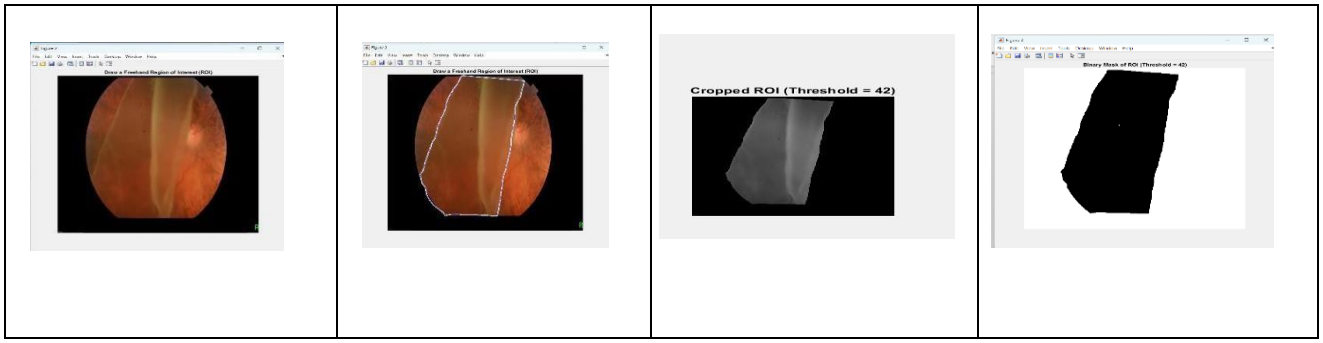


Fig 6. Selection of Retinal detachment using ROI

Table of Comparison result of normal retina and Retinal detachment position using ROI .

Sr. no	Image Name	ROI measurement	Sr. no .	Image Name	ROI measurement
1	129_output.jpg	1.5	21.	333_output.jpg	14
2	1ffa935f-8d87-11e8-9daf-6045cb817f5b._output.jpg	3	22.	119_output.jpg	17
3	96_output.jpg	3	23.	342_output.jpg	17.5
4	254_output.jpg	7	24.	52_output.jpg	17.5
5	an1.jpg	9	25.	48_output.jpg	18
6	b5.jpg	9	26.	Img1.output.jpg	18.5
7	b4.jpg	10	27.	33_output.jpg	19
8	414_output.jpg	10.5	28.	464_output.jpg:	20
10.	BC2.jpg	11	30.	387_output.jpg	21.5
11.	b3.jpg	13	31.	37_output.jpg	22
12.	398_output.jpg	13.5	32.	539_output.jpg	22
13.	BC3.jpg	14	33.	115_output.jpg	23
14.	b1.jpg	14	34.	210_output.jpg	23
16.	ASRS-RIB-output.jpg	29	36.	443_output.jpg	27
17.	b13.jpg	31	37.	27_output.jpg	28
18.	549_output.jpg	31	38.	299_output.jpg	28
19.	607_output.jpg	32	39.	1ffa9354-8d87-11e8-9daf-6045cb817f5b._output.jpg	28.5
20.	469_output.jpg:	34	40.	b14.jpg	29

Table 4: Comparison result of normal retina and Retinal detachment position Using ROI

Classifier used for Classification

In the image preprocessing stage, classification plays a crucial role in preparing retinal images for accurate segmentation and analysis. This step involves the preliminary categorization of input images based on features. By classifying images prior to segmentation, only those that meet predefined quality standards are forwarded for further analysis, thereby improving the overall reliability of the system.

Fuzzy Based Classification Techniques:

Fuzzy-based classification in image processing is a technique that uses to classify pixels, regions, or entire images based on features that may be uncertain, vague, or overlapping.

Fuzzy-based classification refers to the decision-making stage where the system uses to assign a class label to an input based on its characteristics.

1. **Fuzzy C-Means (FCM):** Fuzzy C-Means (FCM) Clustering Classification is an unsupervised clustering technique particularly useful in applications like image segmentation and medical diagnosis. In Our research we apply the fuzzy C-Means (FCM) Clustering Classification techniques used on statistical value of color of retina and area of retina. the values we get using threshold value is overlapping values so, by using Fuzzy c means clustering classification techniques works on the overlapping values, and make the three clusters i.e. shows Primary Stage, Partially Detach and all detach.

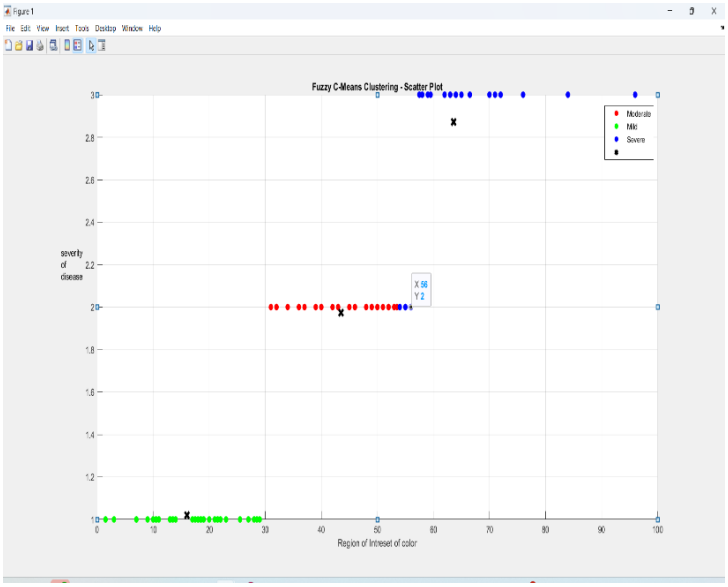
2. **Fuzzy k-Nearest Neighbors (Fuzzy KNN):** A variation of the k-NN algorithm that uses fuzzy membership values to determine the nearest neighbors. In Our research we apply the fuzzy KNN Classification techniques used on statistical value of color of retina and area of retina. the values we get using threshold value is overlapping values so, by using Fuzzy KNN classification techniques works on the overlapping values, and classifies the Retinal detachment disease on the basis of Statistical values i.e. shows Primary Stage, Partially Detach and all detach.

3. **Support vector machine (SVM) Classification:** Support Vector Machine (SVM) is a powerful supervised learning algorithm used for binary and multiclass classification tasks. For making the comparison with Fuzzy Based classification techniques we apply SVM Classification techniques for getting better result. we apply the SVM Classification techniques on statistical value of color of retina and area of retina for classifies the Retinal detachment disease on the basis of Statistical values i.e. shows Primary Stage, Partially Detach and all detach.

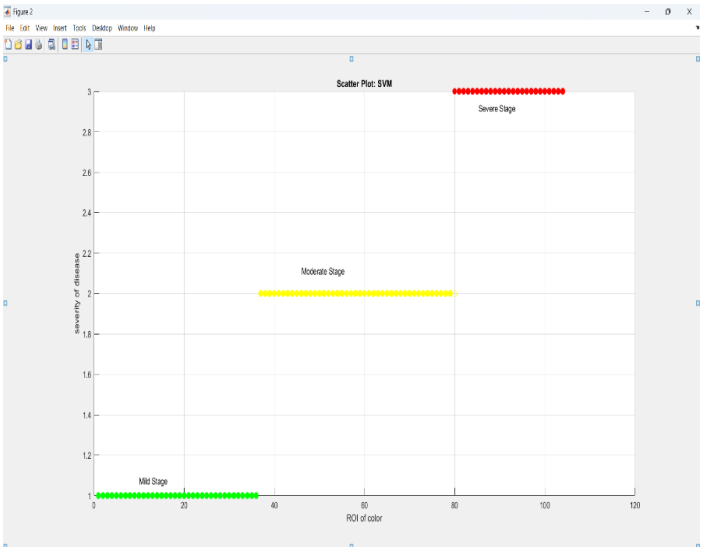
7.3.1 Scatter Plot for Classifiers -

1) Color of Retina Selected using ROI

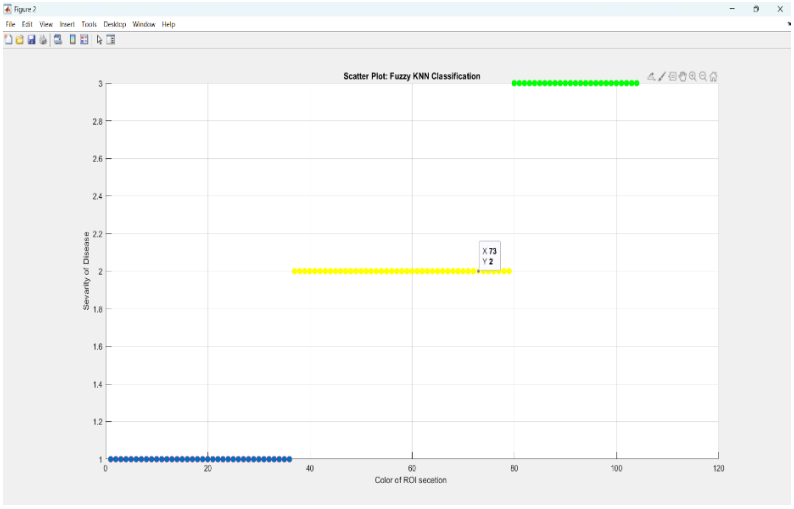
Fuzzy C means Clustering



SVM Algorithm



Fuzzy KNN Algorithm

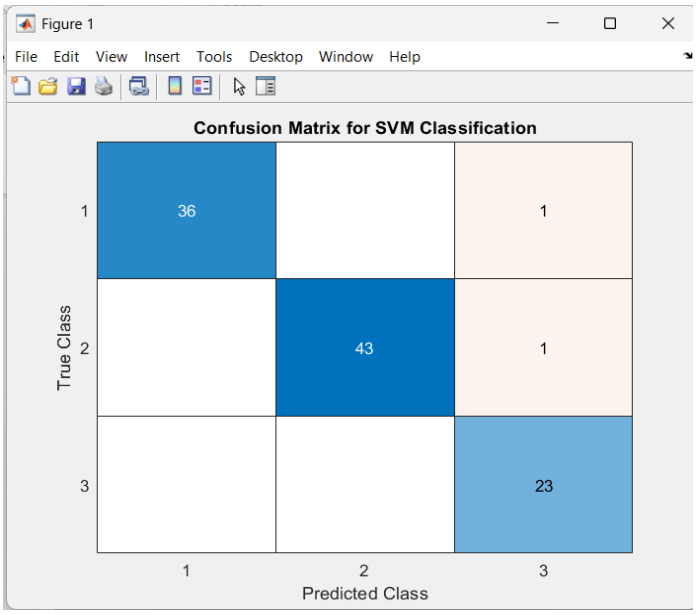


7.3.2. Confusion Matrix Color of Retina

Confusion matrix represents the performance of the algorithm. Where the row is the predicted class and column is the actual class or true class**.** In following figure, we can see all classifier Number of the observation and comparatively Support vector machine and Decision tree gives good result.

Fuzzy C means Classification

SVM Classification



Fuzzy KNN Classification

7.3.2. Result of Classification

Accuracy: The ratio of correctly predicted instances (both true positives and true negatives) to the total instances.

$$Accuracy = \frac{Total\ Correct\ Prediction}{Total\ number\ of\ Sample}$$

Precision: The ratio of true positives to the total predicted positives — it measures how many selected items are relevant.

$$\text{Precision (Pi)} = \boldsymbol{P_i} = \frac{\boldsymbol{TP_i}}{\boldsymbol{TP_i + FP_i}}$$

Recall: The ratio of true positives to all actual positives — it measures how many relevant items were selected.

$$\text{Sensitivity (Recall) (Ri)} = \boldsymbol{R_i} = \frac{\boldsymbol{TP_i}}{\boldsymbol{TP_i + FN_i}}$$

F1 Score: The harmonic mean of precision and recall — it balances both false positives and false negatives

$$\text{F1-score (F1)} = \boldsymbol{F1_i} = \mathbf{2} \times \frac{\boldsymbol{P_i \times R_i}}{\boldsymbol{P_i + R_i}}$$

Result of Color of Retina

Fuzzy C means Classification Result

Metric	Primary Stage (Class 1)	Partially Detached (Class 2)	All detach (Class 3)	Overall
Accuracy	-	-	-	95.19%
Precision	100.00%	100.00%	83.33%	
Recall	100.00%	88.37%	100.00%	
F1-Score	100.00%	93.83%	90.91%	

SVM Classification Result

Metric	Primary Stage (Class 1)	Partially Detached (Class 2)	All detach (Class 3)	Overall
Accuracy	-	-	-	98.04%
Precision	100.00%	100.00%	92.00%	
Recall	97.30%	97.7 %	100.00%	
F1-Score	98.60%	98.08%	95.08%	

Fuzzy KNN Classification

Metric	Primary Stage (Class 1)	Partially Detached (Class 2)	All detach (Class 3)	Overall
Accuracy	-	-	-	99.04%
Precision	97.30%	100.00%	100.00%	
Recall	100.00%	100.00%	100.00%	
F1-Score	98.63%	100.00%	100.00%	

Conclusion

- Among the three classification techniques, Fuzzy KNN achieved the highest accuracy (99.04%), followed by SVM (98.04%) and Fuzzy C-Means (95.19%).
- Fuzzy KNN outperformed others with perfect precision, recall, and F1-score across all classes, indicating 100% correct classification for each retinal detachment stage.
- Fuzzy C-Means showed lower accuracy due to misclassification in the partially detached class (recall = 0.8837).
- SVM demonstrated high precision and recall, but slightly lower recall (0.96) for the fully detached retina.
- Fuzzy KNN achieved perfect classification performance, making it the most reliable method for detecting retinal detachment.

7.4 Experiment No 4:

Retinal detachment diagnosis using Retina Area

Detection of retinal area of normal retina and retinal detachment retina as follows.

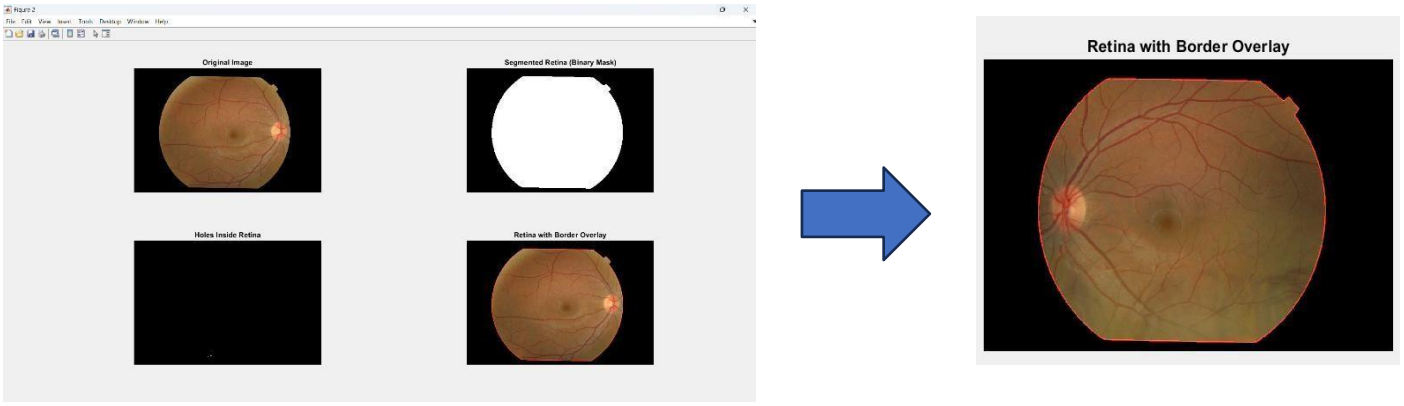
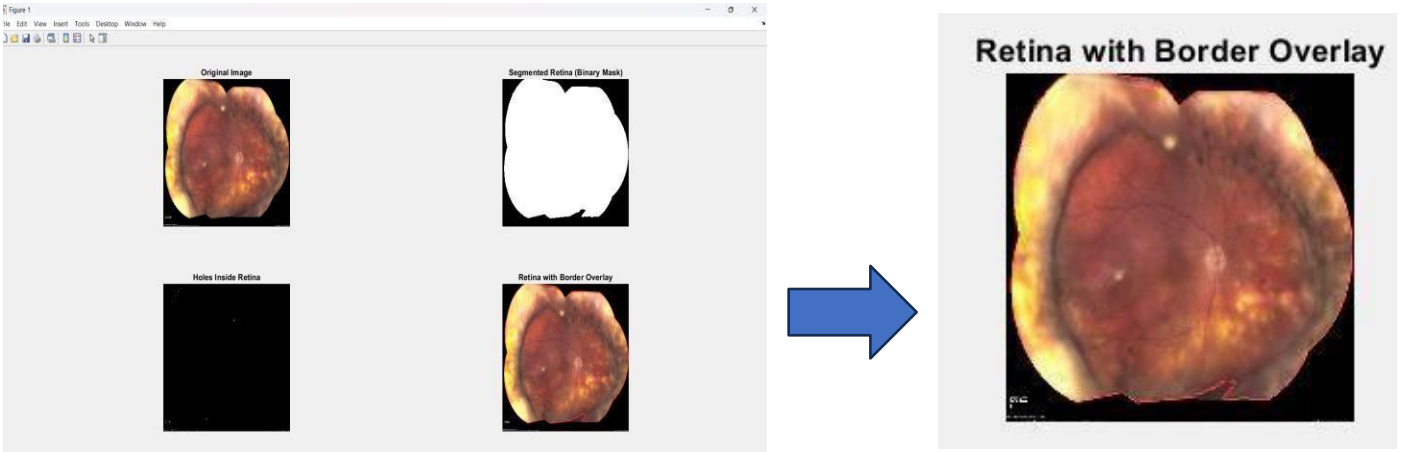


Fig 7: Normal Retina



Retinal Detachment Retina

Fig 8: Retinal Detachment Retina

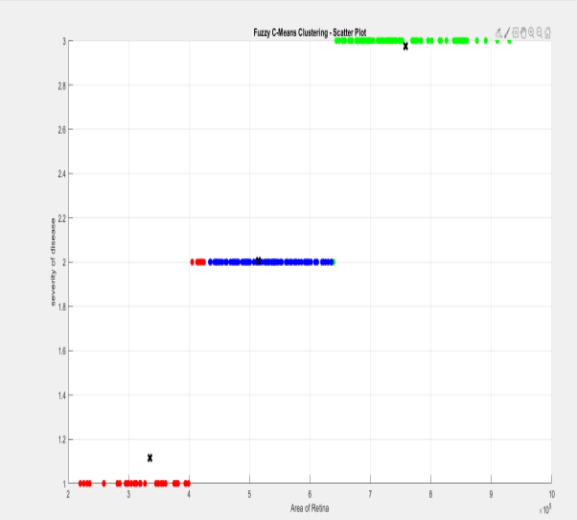
Table of Comparison result of normal retina and Retinal detachment area. These are the samples we work on 400 images

Normal Retina area		Detachment Retina area	
IM000003_20.jpg	816421	ASRS-RIB-Image-61191_output.jpg	345299
IM000004_1.JPG	815995	ASRS-RIB-Image-19704_output.jpg	348854
IM000004_10.JPG	817031	254_output.jpg	349304
IM000004_11.JPG	816902	RD4_output.jpg	353916
IM000004_12.JPG	815476	macula on RD_output.jpg	357151
IM000004_13.JPG	815335	55_output.jpg	495521
IM000004_14.JPG	818682	342_output.jpg	495524
IM000004_15.JPG	815739	490_output.jpg	495526
IM000004_16.JPG	815332	43_output.jpg	495543
IM000004_17.jpg	816371	ASRS-RIB-Image-5234_output.jpg	569514

Table 5: Table of Comparison result of normal retina and Retinal detachment area

7.4.1 Scattered plot of Area of Retina

Fuzzy C means Clustering



SVM Classification

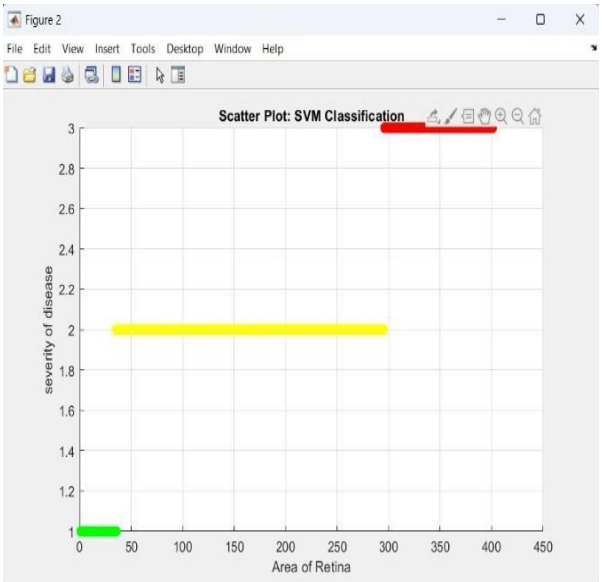


Figure 2
File Edit View Insert Tools Desktop Window Help
Scatter Plot: SVM Classification
severity of disease
Area of Retina

Fuzzy KNN Algorithm

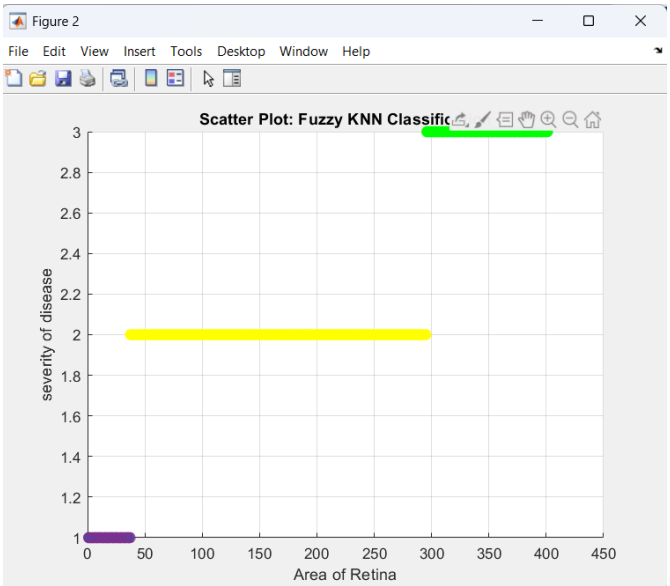
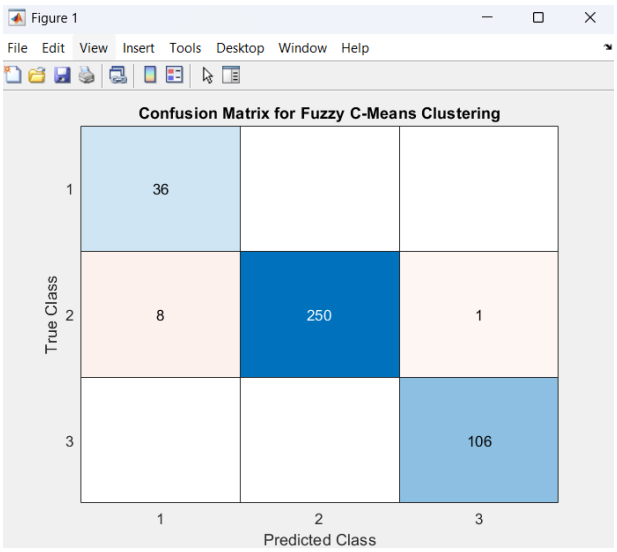


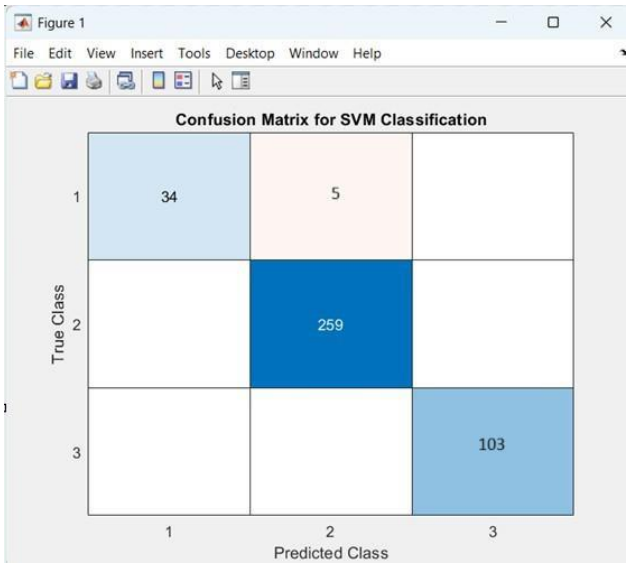
Figure 2
File Edit View Insert Tools Desktop Window Help
Scatter Plot: Fuzzy KNN Classific
severity of disease
Area of Retina

7.4.2. Confusion Matrix of Area of Retina

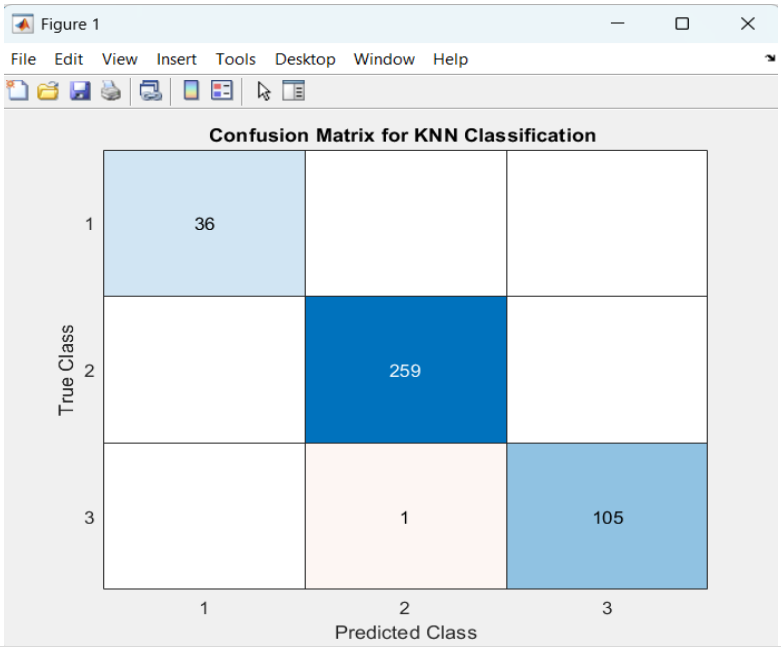
fuzzy c means clustering algorithm



SVM Classification



Fuzzy KNN Algorithm



7.4.2 Result Calculation Area of Retina

Fuzzy C Means Classification

Metric	Primary Stage (Class 1)	Partially Detached (Class 2)	All detach (Class 3)	Overall
Accuracy	-	-	-	97.76%
Precision	81.81%	100.00%	99.07%	
Recall	100.00%	96.53%	100.00%	
F1-Score	89.97%	98.16%	99.53%	

SVM Classification

Metric	Primary Stage (Class 1)	Partially Detached (Class 2)	All detach (Class 3)	Overall
Accuracy	-	-	-	98.75%
Precision	100.00%	98.11%	100.00%	
Recall	87.18%	100.00%	100.00%	
F1-Score	93.15%	99.04%	100.00%	

Fuzzy KNN classification

Metric	Primary Stage (Class 1)	Partially Detached (Class 2)	All detach (Class 3)	Overall
Accuracy	-	-	-	99.50%
Precision	100.00%	99.62%	99.06%	
Recall	100.00%	99.62%	99.06%	
F1-Score	100.00%	99.81%	99.53%	

7.4.4 Conclusion of Experiment

1. Fuzzy KNN classification achieved the highest accuracy (99.50%), followed by SVM (98.75%) and Fuzzy C-Means (97.76%).
2. This indicates that Fuzzy KNN is the most effective method in correctly classifying retinal detachment stages.
3. Fuzzy KNN performed best across all metrics, making it the ideal choice for classifying retinal detachment.
4. SVM also performed well but had minor misclassifications in Class 1.
5. Fuzzy C-Means, while still effective, had the lowest accuracy and F1-score, indicating room for improvement.

8 Conclusion

The presence of floaters in the vitreous gel is an early symptom of retinal detachment, indicating a potential risk of the condition. This symptom can serve as a key parameter in diagnosing the initial stage of retinal detachment

The blood vessel analysis in retinal images. The x-axis represents image filenames, while the y-axis indicates diagnosis values: 1 for RD (Retinal Detachment) and 2 for NRD (Non- Retinal Detachment). Most images fall under NRD, while a few indicate RD, signaling potential detachment risk. This analysis aids in distinguishing normal from detached retinal conditions, essential for early detection and treatment.

The comparative study of classification techniques—Fuzzy C-Means, Support Vector Machine (SVM), and Fuzzy K-Nearest Neighbors (Fuzzy KNN)—for diagnosing retinal detachment

Color of retina Classification Performance

- Fuzzy KNN stands out with the highest accuracy (99.04%) and almost perfect metrics across all classes, indicating it is the strongest performer among the three methods.
- SVM also shows excellent performance (98.04% accuracy) with consistently high precision, recall, and F1-scores for each class.
- Fuzzy C-Means performs well (95.19% accuracy) but lags behind the other two methods primarily because of lower precision on Class 3.
- Overall, Fuzzy KNN is the most effective classification technique for Color of retinal detachment diagnosis, as it ensures no misclassification, making it the ideal choice for high-precision medical diagnosis.

Retinal Area Classification Performance

- Fuzzy KNN classification achieved the highest accuracy (99.50%), followed by SVM (98.75%) and Fuzzy C-Means (97.76%).
- This indicates that Fuzzy KNN is the most effective method in correctly classifying retinal detachment stages.
- Fuzzy KNN performed best across all metrics, making it the ideal choice for classifying retinal detachment.
- SVM also performed well but had minor misclassifications in Class 1.
- Fuzzy C-Means, while still effective, had the lowest accuracy and F1-score, indicating room for improvement.

This comprehensive study underscores the significance of advanced classification techniques in retinal detachment diagnosis, demonstrating that Fuzzy KNN provide the most accurate and efficient solutions for medical image classification and early disease detection

9. Major Contribution

The current research work focuses on the diagnosis of Retinal Detachment (RD) disease using Optical Coherence Tomography (OCT) and Ultra-Widefield (UWF) fundus images. A comprehensive literature review reveals that existing studies primarily analyze retinal floaters and blood vessels as key diagnostic features. However, there is limited exploration of additional retinal characteristics that could enhance the accuracy of RD diagnosis.

In this research, we aim to introduce and extract new features for retinal detachment detection under the guidance of ophthalmologists. These features include:

- Color variations in the detached retinal area
- Blood vessel
- Retinal area measurement
- Floaters present in the vitreous fluid

The dataset used for this study consists of authorized retinal detachment fundus images, ensuring reliability and standardization in data collection. Unlike previous research that primarily focuses on floaters and blood vessels, our approach integrates multiple retinal features, providing a more comprehensive assessment of retinal detachment.

To achieve high diagnostic accuracy, we apply various fuzzy-based classification techniques to classify the stages of retinal detachment. These techniques are evaluated to determine their effectiveness in enhancing diagnostic precision. Additionally, expert opinions from ophthalmologists are incorporated into the analysis to validate the results and further improve the classification performance.

Key Contributions of This Research:

1. New Feature Extraction for Retinal Detachment: Expanding beyond floaters and blood vessels by analyzing color, retinal area, and vessel morphology for better diagnosis.
2. Expert-Guided Validation: Collaborating with ophthalmologists to enhance feature selection and classification reliability

10 Research Papers Presented & Publication

Research Papers Presented:

1. Research paper Presented One Day International Multidisciplinary E- Conference on " The New Education Policy and Research Orientation among Students and Faculty "organized By Burhani College, University f Mumbai in collaboration with Guru Angad Dev Teaching Learning Center, SGTB Khalsa College , University Of Delhi Under the Pandit Madam Mohan Malaviya National Mission On Teachers and Teaching (PMMMNMTT) of Ministry of Education held on 27th August 2022.

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Government of India
Ministry of Education

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Burhani College
Affiliated to University of
Mumbai

Certificate

This is to certify that

ANJALI ARUN ROKDE, DR. G.Y.PATHRIKAR COLLEGE OF CS & IT

has **Successfully Presented a Paper** entitled **"Diagnosis of Retinal Detachment Using Biomedical Image Processing Technique-Review"** in One-Day International Multidisciplinary E-Conference on **"The New Education Policy and Research Orientation among Students and Faculty"** organized by Burhani College, University of Mumbai in collaboration with Guru Angad Dev Teaching Learning Centre, SGTB Khalsa College, University of Delhi under the Pandit Madan Mohan Malaviya National Mission on Teachers and Teaching (PMMMNMTT) of Ministry of Education held on **27th August 2022**.

Prof. Jaswinder Singh
Principal
S.G.T.B. Khalsa College
University of Delhi

Dr. Talib Yusuf Abbas Hussain
Dean of Academic Affairs
Burhani College
University of Mumbai

Prof. Vimal Rarh
Project Head & Joint Director
GAD-TLC of Ministry
of Education

UNIQUE CERTIFICATE CODE: GAD-TLC/2022-23/INTWEB4/PP-022

2. Research Paper digitally presented on Two day's "7th International Conference on Information and Communication Technology for Competitive Strategies "Organized by Global Knowledge Research Foundation (ICTCS-2022) on 9th - 10th December Chandigarh, India.

ICTCS 2022

CERTIFICATE

THIS IS TO CERTIFY THAT

Anjali A. Rokde

HAS DIGITALLY PRESENTED A PAPER TITLED

FLOAT PARAMETER EXTRACTION FROM RETINAL FUNDS IMAGE IN THE DIAGNOSIS PROCESS OF RETINAL DETACHMENT

AT THE

SEVENTH INTERNATIONAL CONFERENCE ON

INFORMATION AND COMMUNICATION TECHNOLOGY FOR COMPETITIVE STRATEGIES

ORGANIZED BY

GLOBAL KNOWLEDGE RESEARCH FOUNDATION

9-10 DECEMBER, 2022

7th Edition ICTCS 2022

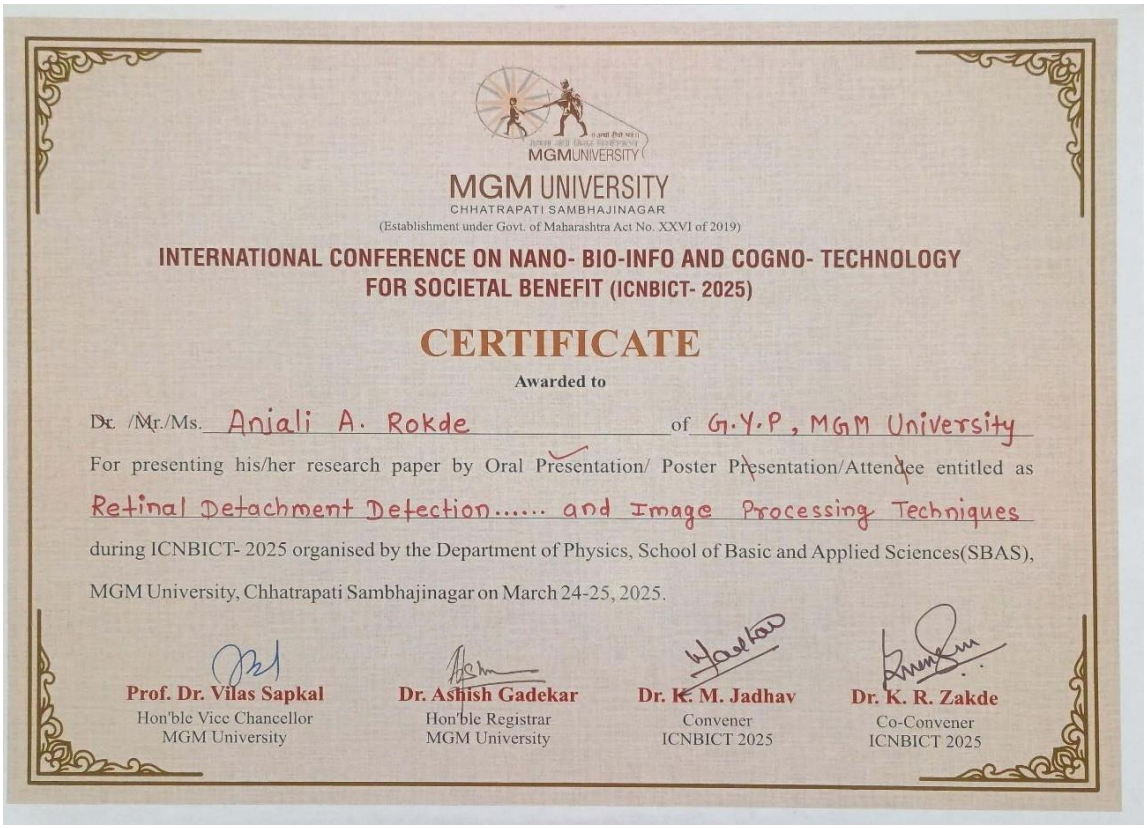
DIGITAL PLATFORM : ZOOM

Dr. NILANJAN DEY
PROGRAM CHAIR

Dr. AMIT JOSHI
ORGANISING SECRETARY

Mr. MIHIR CHAUHAN
PROGRAM SECRETARY

3. Retinal detachment detection using Blood Vessel Analysis and Image Processing Techniques"- Presented in International conference on Nano -Bio-Info and Congo Technology For Societal Benefit (ICNBICT-2025)



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INTERNATIONAL CONFERENCE ON NANO- BIO-INFO AND COGNO- TECHNOLOGY FOR SOCIETAL BENEFIT (ICNBICT- 2025)

CERTIFICATE

Awarded to

Dr. /Mr./Ms. Anjali A. Rokde of G.Y.P, MGM University

For presenting his/her research paper by Oral Presentation/ Poster Presentation/Attendee entitled as

Retinal Detachment Detection..... and Image Processing Techniques

during ICNBICT- 2025 organised by the Department of Physics, School of Basic and Applied Sciences(SBAS), MGM University, Chhatrapati Sambhajinagar on March 24-25, 2025.

Prof. Dr. Vilas Sapkal	Dr. Ashish Gadekar	Dr. K. M. Jadhav	Dr. K. R. Zakde
Hon'ble Vice Chancellor MGM University	Hon'ble Registrar MGM University	Convener ICNBICT 2025	Co-Convener ICNBICT 2025

List of Publication

Paper Presented in Conference: -

1. “Diagnosis of retinal detachment using biomedical image processing Technique-Review” :- Presented in One Day International Level Multidisciplinary E-Conference on “The New Education Policy and Research Orientation among Students and Faculty” conducted by BURHANI COLLEGE, Mazgaon, Mumbai on 27 August, 2022
2. “Float Parameter Extraction from Retinal Funds Image in the Diagnosis Process of Retinal Detachment”, Published in Springer Nature Singapore Pet Ltd. Volume 623 pp 385-395 https://doi.org/10.1007/978-981-19-9638-2_35 , ISSN 2367-3370 ISBN 978-981-19-9637-5, 31 May 2023.

3. Retinal detachment detection using Blood Vessel Analysis and Image Processing Techniques"- Presented in International conference on Nano -Bio-Info and Congo Technology For Societal Benefit (ICNBICT-2025)

Papers Published in Journal:

4. Diagnosis of retinal detachment using biomedical image processing Technique-Review” :- Published in Vidyawarta Peer-Reviewed International Journal , ISSN: 2319 9318, Impact Factor 8.14(IIJIF)

5. "Diagnosis of Retinal Detachment Using Region of Interest (ROI) Based Color Analysis and Fuzzy C-Means Classification" :- Published in at International Journal of Creative Research Thoughts. Scholarly open access journals, Peer-reviewed, and Refereed Journals, Volume 13, Issue 2 February 2025 | ISSN: 2320-2882

6. "DIAGNOSIS OF RETINAL DETACHMENT VIA BLOOD VESSEL ANALYSIS USING MULTI THRESHOLD IMAGE BINARIZATION" - Accepted International Journal of Preventive Medicine & Helath (IJPMH) paper ID C106405030325. This article will be published in Volume- 5 Issue-4 May 2025.

CO-AUTHOR Publications: -

7. UNVEILING THE PRELESION OF SINGLE CELL RNA SEQUENCING AND MACHINE LEARNING IN BREAST CANCER GENE DETECTION Published in at International Journal of Creative Research Thoughts. Scholarly open access journals, Peer-reviewed, and Refereed Journals, Volume 13, Issue 2 February 2025 | ISSN: 2320-2882

8. “ Determination and Prediction of Bosom Malignant Genes Growth Utilizing scRNA Sequencing Information by AI Applications” Published in Springer Nature Singapore Pet Ltd. Volume 623 pp 407-416, https://doi.org/10.1007/978-981-19-9638-2_35, , ISSN 2367-3370 ISBN 978-981-19-9637-5, 31 May 2023

9. Comparative Performance of Machine Learning Classifiers on Genomic Dataset for Gene Expression-Based Breast Cancer Disease Classification- Accepted in International conference on Nano -Bio-Info and Congo Technology For Societal Benefit (ICNBICT-2025)

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